

## RESEARCH ARTICLE

# Conceptual design of a health suit to prevent COVID-19 and similar type other airborne virus infections

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G. M. Palya, Bengaluru-560 075, India.  
Email: sinha.srikanta@gmail.com**Abstract**

We present the conceptual design of a complete health suit. This suit is designed to provide clean, virus-free air to its wearer either from an oxygen cylinder or through an air purification system that consists of an ultraviolet lamp, or a soap solution-based air purifier. This health suit, if designed and fabricated properly, should help prevent the spread of COVID-19 and similar type other airborne virus infections in human beings.

**KEYWORDS**

COVID-19 and similar other airborne viruses, health suit, prevention, soap solution, ultraviolet lamp

## 1 | INTRODUCTION

In the present situation, the novel coronavirus-2019 (COVID-19) is the most severe global health problem. The viral infections caused by the novel coronavirus (SARS-CoV-2) was first reported (Huang et al., 2020; Wang et al., 2020; Wu et al., 2020; Zhou et al., 2020), to have emerged in the city of Wuhan in the Hubei province in the Peoples' Republic of China (PRC). It causes high fever, severe respiratory problems and pneumonia. It is a human pathogen that has spread exponentially throughout the world causing a very large number of deaths, and this pandemic has given a shocking blow to the global economy. It is extremely important to be able to arrest the further spread of this highly infectious disease (Edemekong & Huang, 2020; Guo et al., 2020) and find ways and means to cure this disease. Global efforts are on to develop vaccines or other ways of curing this deadly disease, viz. monoclonal antibodies (Dimitrov, 2010), peptide oligonucleotide-based therapies (Gissberg et al., 2019), interferon therapies and small molecule drugs (Bahl et al., 2017; Murphy & Whitehead, 2011).

Currently, face masks (Feng et al., 2020) are being used widely throughout the globe as a preventive measure against the COVID-19 and similar viral infections. However, wearing just a face mask in public places is not a very effective preventive measure against COVID-19 type viral infections, since its use has several disadvantages (Matuschek et al., 2020; Spitzer, 2020).

1. Using a face mask we are not able to breathe and speak properly,
2. If it is not worn properly, the nose and mouth may not be fully covered,
3. Other portions of the face which are not covered by the mask may be affected by the respiratory droplets released by an infected person, and
4. The person may get infected with coronavirus by touching a surface which is already contaminated by the virus and then touching his/her own mouth or nose etc.

Hence, a complete health suit is needed in order to provide almost a hundred per cent protection against this deadly virus.

However, these endeavours are likely to succeed only within timescales of many months or even years. In the present paper, we make an attempt to describe the conceptual design of a complete health suit which is, in principle, similar to the spacesuits used by astronauts/cosmonauts during space missions. This may be produced rather cheaply and easily. The earth suit may be used by health workers, industrial and agricultural workers as well as the general public in order to prevent the infection caused by the novel coronavirus and similar other airborne viruses. The structure of this paper is as follows. In Sec. II, we discuss the conceptual design and three different approaches. In Sec. III, we made our conclusion.

## 2 | THE CONCEPTUAL DESIGN

The fibreglass helmets used in spacesuits are designed to withstand the large (1 atm.) pressure difference between the air inside the helmet and that of outer space which is practically zero. On the other hand, if this type of fibreglass (transparent) is to be used by humans on the Earth's surface, the design requirements are far less stringent. In fact, fibreglass helmets (non-sealed type) are used presently by bike riders almost universally. But what we need are helmets that completely enclose the human head and shoulder. Hence, these have to be necessarily transparent and near-spherical in shape. There has to be a leak-proof rubber or neoprene gasket (an O-ring similar to that used in pressure cookers). A collar with a circular groove has to be fixed on the shoulder of the helmet user on which this O-ring will sit and thus make it leak-proof. A microphone and a pair of headphones are to be placed inside the helmet. The lead wires from these will be connected to a cell phone that may be housed in the chest pocket of the suit (described later). Figure 1 gives a schematic diagram of the helmet.

Next comes the requirement of providing purified or clean air within the spherical volume of the helmet. At this moment, we are able to think of essentially three different alternatives.

### 2.1 | Approach (I)

Carrying a small oxygen cylinder as a backpack with a controlled release valve that will inject pure air within the helmet is a reasonable solution. Light-weight (about 3.4 kg) oxygen cylinders are available in the market at reasonable (less than 100 USD each) prices that are able to provide oxygen supply at the rate of about 2 litre/minute for about two to two and half hours. This type of cylinders (fitted with control valves) has the following dimensions: (a) height = 42.5 cm, (b) diameter = 11.4 cm. and may easily be fitted at the back of a person using straps.

### 2.2 | Approach (II)

In the second approach, there is no need to carry an oxygen cylinder. Instead, one has to carry say, a 12 volts or even 6 volts rechargeable battery, say, 7.5 Ah as a backpack (even otherwise, a battery consisting of 4, or 6 number of D-size dry cells will do the job, in emergency). In addition to the battery, the backpack should have an air purifier that consists of the following: (i) a small cylindrical quartz mercury

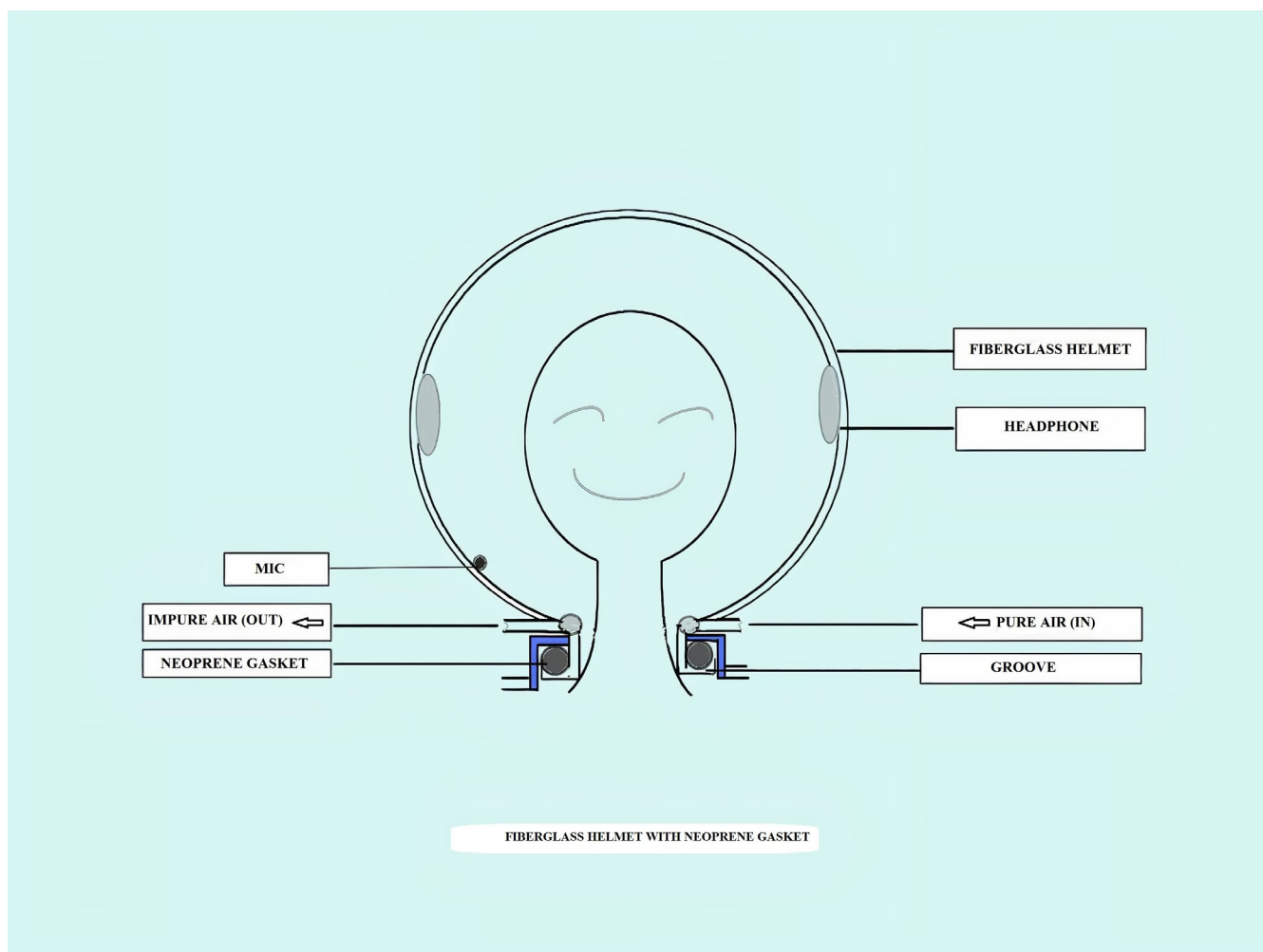
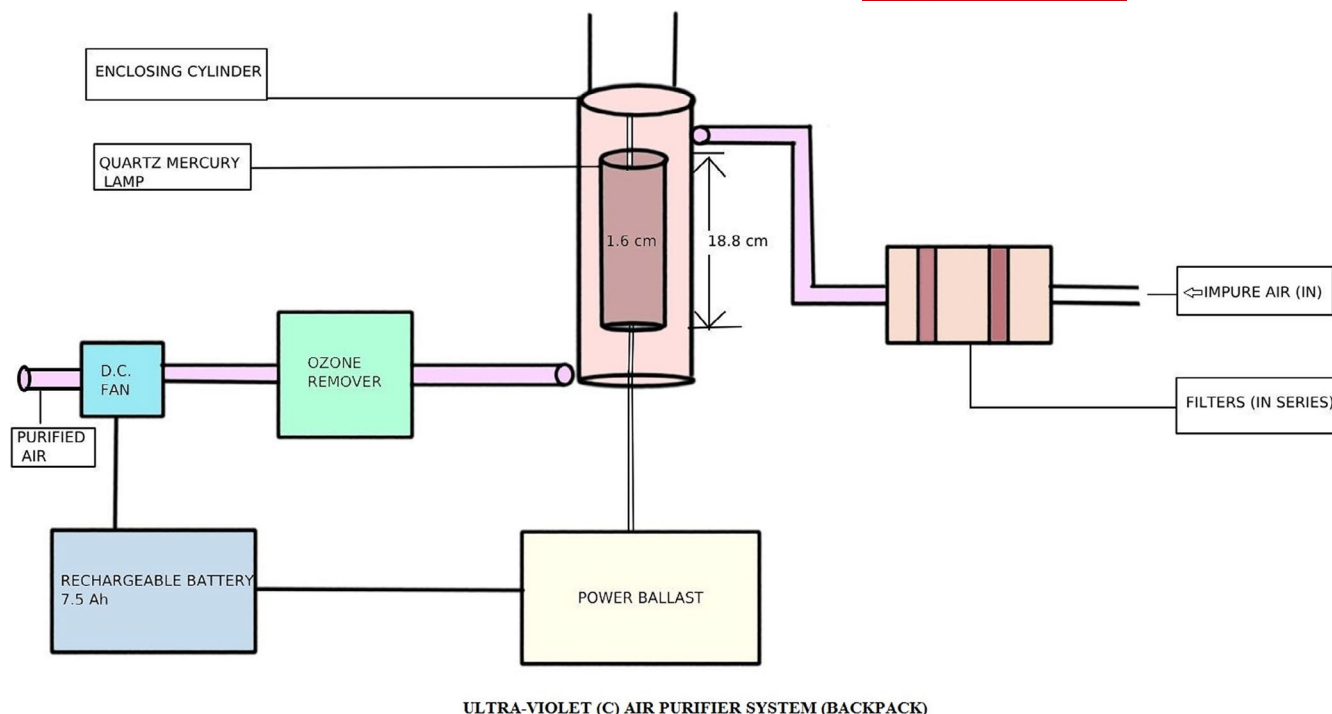


FIGURE 1 Schematic diagram of the helmet mounted on a gasket



**FIGURE 2** Schematic diagram of the ultraviolet lamp-based air purifier system

discharge lamp that will generate UV-C radiation using the power from the battery through a power ballast (these are readily available in the market). This type of quartz mercury lamps is used at present in many brands of home water purifiers. Also, there has to be a small DC fan (again these are available in the market and are quite cheap). This fan will be used to suck out the foul air from inside the helmet while air from outside will enter a small side hole in the body of the helmet through a small stainless steel tube surrounding the quartz mercury lamp. Also, it will be better if a small air filter (N-95 or similar type) is fixed at the entrance of the tube. When UV-C radiation is used to kill virus in air, a minimum interaction time is needed to kill the virus. Therefore, the speed of air has to be kept at a low level to allow for this minimum interaction time. The linear size of the quartz mercury lamp used in home water purifiers is about 18.8 cm and its diameter is about 1.6 cm. The interaction time ( $\tau$ ) is determined by the speed ( $v$ ) of the air

$$\tau = \frac{l}{v} \quad (1)$$

here  $l$  is the length of the quartz mercury lamp. The interaction time (for the same speed of air) may be increased by placing two, three or four quartz mercury lamps consecutively along their length. To save space and make the system compact, two such lamps may be arranged in L shape, three such lamps may be arranged in a U shape or four such lamps may be arranged in a square shape. The cylindrical tubes that enclose individual lamps have to be joined through short sections of quartz tubes.

Another solution may be is to use a single mercury discharge lamp having large enough length. This tube may even be of a circular shape in order to save space. But this solution is not desirable,

since in that case the high voltage needed will be very large and the chance of getting an electrical shock (in case of weak and improper insulation) will be very high.

A small amount of ozone gas will be produced by the interaction of UV-C radiation with the incoming air. This ozone gas will have to be removed subsequently by using an ozone filter. Figure 2 gives a schematic diagram of the UV-C air purifier system.

Air from outside enters the stainless steel cylinder through the filter box. The filter box consists of a set of filters (preferably N-95 type, but the filter box is replaceable from time to time). Inside the stainless steel cylinder is placed the quartz mercury discharge lamp. The incoming air travels down through the annular space between the stainless steel cylinder and the mercury lamp, thus getting exposed to the UV-C radiation. The viruses get destroyed due to exposure to this radiation. The UV-C lamp is driven by the power ballast, which gets power from the rechargeable battery. This battery also drives the D.C. fan which sucks the purified air from the SS cylinder. Air enters the top of the SS cylinder due to the sucking action of the fan.

### 2.3 | Approach (III)

In the following, we try to describe another simple method to sterilize the virus-infected air. It is well known that washing using soaps kills virus. If we are able to produce bubbles in a soap solution using the virus-infected air, it is possible to remove the virus. However, if the size of the bubbles is large, only the virus present on the surface of a bubble would be killed but not those inside the bubble.

Therefore, we propose to produce microscopic bubbles by injecting the virus-infected air into a soap solution using small needles, for example that are used by health professionals to give injections to medically sick persons. In this case, micro-bubbles will be produced and there is a high probability of any single virus being killed. To increase the efficiency of the system, we propose to use N-95 type filters in the path of the incoming air.

A minimum interaction time (of the order of 20 seconds or a little more) is needed to kill the virus in soap solutions. Therefore, the speed of the incoming air has to be maintained sufficiently low. To have an efficient working device, one should have a stainless steel cylinder filled with the soap solution. A somewhat wide (say, 20 mm diameter) tube having several nodes along its length where each node will have at least one air filter will be good enough to purify the air that will be sucked in by using an air pump (similar to that used in home aquariums). Micro-bubbles will be produced when this filtered air is injected into the soap solution. Figure 3 gives a schematic diagram of the soap solution-based air purifier system.

The spacesuit type helmet described earlier should prove to be helpful in preventing COVID-19 and similar types of viral infections. However, for complete protection of agricultural, industrial and

health workers along with the general public, we propose to develop a complete viral infection prevention suit that will be very similar to the spacesuits used by astronauts/cosmonauts. However, again, the design requirements are much less demanding since we are on the surface of the Earth and are protected from the harsh environments of outer space like zero outside pressure and high levels of radiation, etc.

A complete health suit may be designed and fabricated using materials like canvas (that are used to manufacture some types of rain-coats and air-pillows etc.). These are reasonably cheap and durable materials. Gloves also may be manufactured out of these or similar materials, and rubber shoes should be added to complete the design of the health suit.

There exist a host of materials like different kinds of polymers that may be used to manufacture this type of health suit that is stronger, lighter and more durable. But at the same time these will be somewhat costlier to produce. Truly, a wide range of such suits may be manufactured at ease with the present-day technologies.

After the scheduled duties are over, the worker should take a shower (with the suit on) in water mixed with a good sanitizer to completely disinfect the health suit and then remove the suit and continue his/her normal daily life. The wet suit has to be further

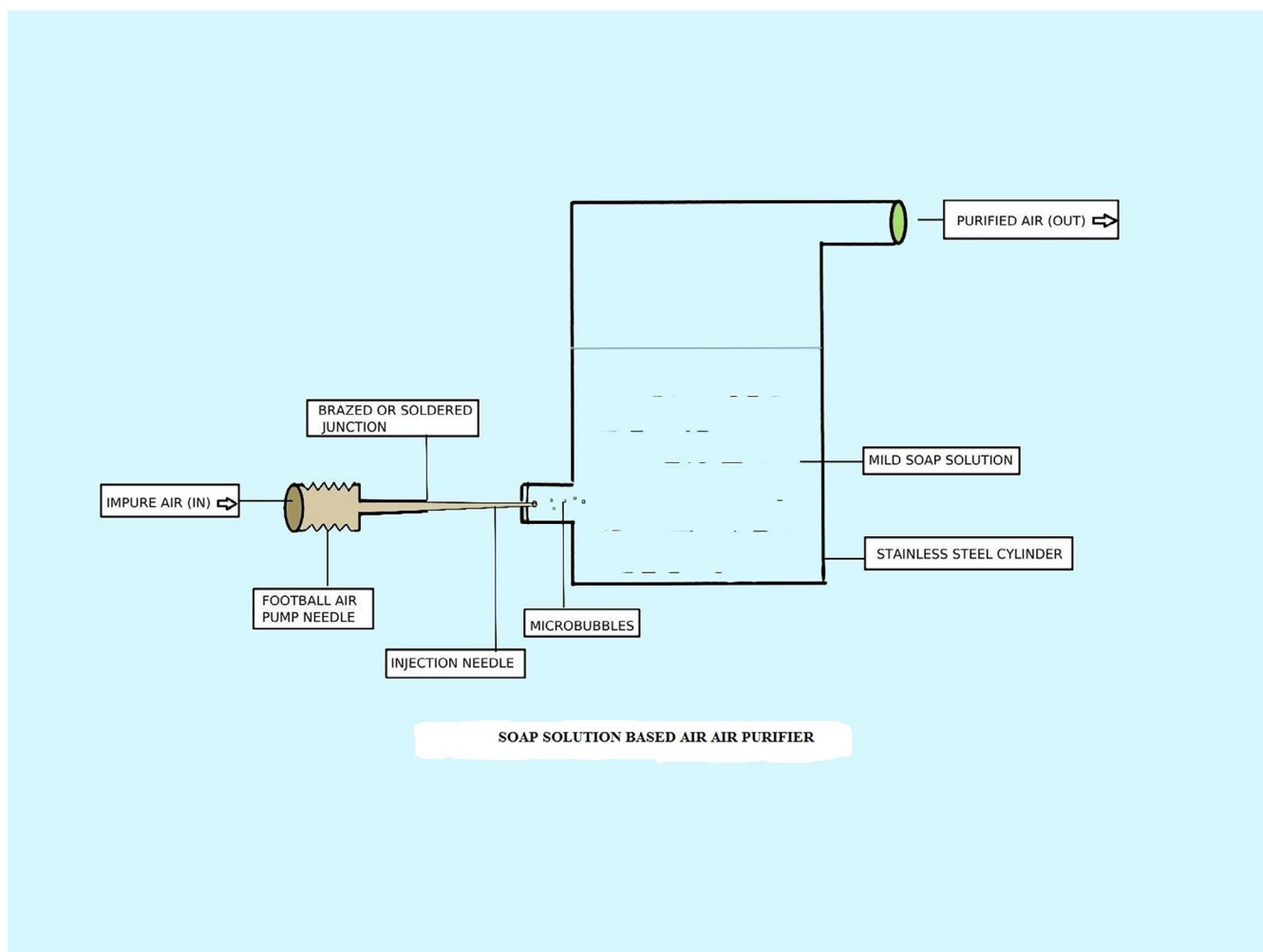


FIGURE 3 Schematic diagram of the soap solution-based air purifier system

washed with mild detergent and dried completely to be ready for use the next day. Here, we have tried to calculate an estimated production cost of the device (however, cost may be varied) as follows:

## 2.4 | Cost estimate

Item	Price (USD)
Oxygen Cylinder	120
Helmet	20
Jacket and Trouser	10
Battery	10
Filter box	5
DC fan	6
Quartz Hg lamp	5
Cooling fan	6
SS cylinder	7
Ballast	5

## 3 | DISCUSSIONS AND CONCLUSION

In summary, our study provides the first conceptual design of a health suit to prevent COVID-19 type and other airborne virus infections. Furthermore, this health suit will be useful for medical professionals working in hospitals or nursing homes. Especially, the first approach is quite suitable and easy to implement for all cases. However, the only hassle will be to change the oxygen cylinders every few hours.

In order to overcome coronavirus and other airborne diseases which are not only a severe health problem but is also a serious threat to the global economy. We should invest money and other resources in research on vaccines, drugs or design devices that can prevent any future global crisis like this kind of pandemic. We hope that our design might help us a lot in preventing this type of severe disease. To get better results, research on the quick design and development of this device is needed.

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